RAPID RIVER COALITION
MAINE DEPARTMENT OF INLAND FISHERIES AND WILDLIFE
TROUT UNLIMITED

SMALLMOUTH BASS/BROOK TROUT HABITAT MANIPULATION STUDIES IN RAPID RIVER, TWP C AND UPTON, OXFORD COUNTY, MAINE

2007 PROGRESS REPORT

MARCH 2008

Prepared by:

Kleinschmidt
Energy & Water Resource Consultants

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EXECUTIVE SUMMARY

Studies were conducted during 2007 to continue the assessment of the effects of flow pulses on reducing smallmouth bass year class recruitment in the Rapid River. In 2005, flow releases from Middle Dam between 1,000 to 1,200 cfs were identified via modeling as potentially stressful for fry and YOY smallmouth bass lifestages but protective of brook trout. In 2006, a pilot study developed methods, and evaluated experimental flow pulses. Despite limited information, the data indicated some potential for pulses to achieve the objective. The 2007 studies:

1. Collected additional data on the effects on bass spawning success of pulse flows.
2. Determined the abundance, distribution, and relative vulnerability of nests to flow changes.
3. Documented growth and relative abundance of young-of-year (YOY) and yearling smallmouth bass following flow pulse experiments.

The effect of flow pulses was monitored at 14 nests, using the same methods developed in 2006. In addition, a snorkeling survey was conducted along the shoreline of all riverine habitat to inventory nest distribution and classify nests by cover quality. Rapid River smallmouth bass growth, abundance and catch rate data were collected and compared to historic data. 2007 findings indicate that:

- black fry appear to consistently reach their greatest abundance and vulnerability during the week spanning the end of June and beginning of July.
- spawning occurs in temporal cohorts spaced several days apart.

- Although some nesting sites are reused annually, sites selection appears influenced by prevailing base flows, with lower base flows resulting in increased nest construction in flow-vulnerable areas.
- Nesting occurs in habitats with low velocity and depths between 3-5 ft at all flows. Most nests were limited to littoral areas of deep pools, runs/glides. No nesting was observed in rapids and riffles lacking sufficient depth and cover (i.e., near shore depths of 3 or more ft, and dense boulder cover).
- The 1,200 cfs pulse flows were approximately 50% effective overall at causing nests to fail to produce viable offspring..
- YOY data suggests a negative correlation between erratic flows and juvenile bass recruitment and a positive correlation to trout abundance; although the mechanisms are not fully understood, continuing a program to provide pulse flows from Middle Dam that stress young bass seems desirable

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2007 PROGRESS REPORT

1.0 INTRODUCTION

The Rapid River has historically provided a unique, high-quality coldwater sport fishery, most noted for large native brook trout (greater than four pounds). Smallmouth bass illegally introduced to Umbagog Lake in the 1980's have invaded the Rapid River, where they compete with, and prey on, native brook trout.

The Rapid River Coalition, comprised of conservation interests and MDIFW (Coalition) is collaboratively exploring methods to manage and reduce the effects of the river's smallmouth bass population on the brook trout population. There is considerable evidence in the scientific literature that erratic spring and summer flows reduce reproductive success of riverine smallmouth bass sufficiently to impair year class strength. In a study on several Virginia rivers, Smith, et al.(2005) found that: "*In general, there are many mechanisms whereby high flows during and immediately after spawning can lead to reduced recruitment of smallmouth bass… High flows can scour nests, displace fry, or both during life stages when they are very sensitive to high water velocities... The impacts of high flows on smallmouth bass recruitment have been well documented and are almost universally negative…Moderate flows during and immediately after spawning may be necessary to produce the strongest year-classes of smallmouth bass*."

Lukas and Orth (1995) determined that *"Increased water velocity at nest sites with increased stream discharge was the most likely cause of nest failures. The increase of mean velocity with increased stream discharge was significantly lower for successful nests than for unsuccessful nests, which showed that nest location determines the degree of exposure to high flows. The temporal pattern of streamflow fluctuation appears to be the most important abiotic factor determining nesting success or failure for smallmouth bass in this perennial stream.*"

The Coalition is currently considering river flow manipulation as one means of limiting reproductive success of smallmouth bass to reduce their negative impacts on brook trout.

The 2005 Physical Habitat Simulation (PHABSIM) analysis performed for the Coalition (Kleinschmidt Associates, 2006) predicted that fry and young-of-year (YOY) smallmouth bass in riverine habitat could be vulnerable to flow pulses discharged from Middle Dam exceeding 1,000 cfs during June (fry) and throughout the growing season (YOY). Flow pulses, however are not expected to affect smallmouth bass nesting success in Pond in the River, a lacustrine segment of the river.

To stay within typical operating and water budget constraints, the number and duration of flow pulses was initially proposed as three flow bursts of at least 12 hours duration during periods of smallmouth bass fry emergence. A preliminary investigation of the effectiveness of the flow pulses at displacing and stressing young bass was initiated in 2006. Experimental flow releases suggested that black fry attrition occurred in nests constructed in areas with marginal velocity cover, but there appeared to be little effect on well-sheltered nests. Extended high flows that occurred naturally during June and July, 2006 limited opportunities to conduct more rigorous tests, but showed that high and extended June flows impaired spawning by inducing nest abandonment and delaying re-nesting.

The goals of the 2007 studies were to:

1. Conduct a river-wide nesting survey to determine the abundance, distribution, and relative vulnerability of nests to flow changes. From these data, evaluate the overall efficacy of flow pulses in disrupting vulnerable nests.
2. Collect additional data on the effects on bass spawning success of pulsing flows from 400-600 cfs to 1,200 cfs.
3. Monitor young-of-year (YOY) and yearling smallmouth bass to document their growth and relative abundance following flow pulse experiments conducted in 2006 and 2007.

4. Opportunistically re-assess the effects of late-season peak flows on nest abandonment[1].

[1] There was no opportunity to do this in 2007.

2.0 METHODS

2.1 Nest Survey

The study area for the 2007 nest survey included most of the Rapid River (excluding Pond in the River) that could be accessed and snorkeled safely. To determine the specific start date of this phase of the study, flows, water temperature, and bass behavior were closely monitored by MDIFW staff beginning in mid-June, and a base flow of 400 cfs was provided from Middle Dam. The initial nest survey was conducted by snorkeling potential habitat along the river (Photo 1) at the base flow in late June once nesting was underway. Nest surveys included both left and right banks (looking downstream) of the river in areas with potential bass nesting activity such as runs, pools and glides. Areas of high gradient, rapid, shallow or turbulent flow were examined, and did not provide bass nesting opportunities.

Bass nest cover was rated based on percent area cover within a four-foot radius of each nest (Table 1). Distance to cover from the nest perimeter, description of cover type (*i.e.* boulder or woody debris) and depth of the nest at 400 cfs were also recorded. Nests that were easily accessed and representative were photographed (Appendix A), blazed with a marked iron sash weight and geo-referenced with a hand held Magellan Explorist 400 GPS unit. Marked nests were monitored during the pulse flow tests.

Table 1. 2007 nest survey cover classification for Rapid River flow assessment.

Percent Cover	**Cover Class**
0-25%	Poor
26-50%	Fair
51-75%	Good
76-100%	Excellent

Water temperature was continuously recorded using a STOWAWAY® XTI logger (Onset Corp.) located at Lower Dam (data provided by MDIFW). Daily flow data were manually recorded and provided by FPL Energy Maine.

Photo 1. Typical snorkel observation of active smallmouth nest at Cold Spring Pool (CSP2), Rapid River. A weight with orange flagging was used to non-intrusively mark each nest site. Note proximity of nest to object cover.

2.2 Effects of the 400cfs to 1,200 cfs Pulse during Black Fry Swim-up

The effect of 12-hour, 1,200 cfs flow pulses on smallmouth bass egg mortality, fry attrition, and nest abandonment was more thoroughly evaluated in 2007. Scheduling was determined by monitoring water temperature and bass nesting behavior by MDIFW regional staff, and by coordinating with FPL Energy Maine staff for scheduled flow releases. Accordingly, three flow pulses were released during the evening on June 28, 29 and July 2, 2007.

Instantaneous egg and fry attrition was monitored at both good-cover and poor-cover nests, with snorkeling/viewing bucket observations before and after flow pulses at pre-selected study nests following methods developed in 2006 (Kleinschmidt Associates, 2007). Each study nest was viewed at the 400 cfs base flow prior to and subsequent to a targeted 1,200 cfs flow pulse so that before-and-after estimated counts of egg, sac fry and black fry could be made.

2.3 Young-of-Year (YOY) and Yearling Smallmouth Bass Monitoring

Data documenting growth and relative abundance of YOY smallmouth bass was gathered by MDIFW by back-pack shocking at one index site during May and June 2007. In addition, a 14-ft inflatable electrofishing raft was deployed in the reaches above the Pond in the River inlet and from Lower Dam to Long Pool. This work occurred on September 11 and September 12, 2007 when river discharge was 800 cfs. The electrofishing system included a generator-powered Smith-Root model GPP 2.5, a multi-dropper boom anode, and cathode outriggers on each side of the bow. Cathodes were custom-cut and sufficiently long to reach bottom. The field crew consisted of a driver and a netter. The boat was generally fished from upstream to downstream along a measured length of shoreline, with the boat operator maneuvering and positioning the boat over cover, shoreline pockets and chutes for as long as required to collect fish. All fish were netted and retained in an onboard aerated live well until the end of sampling. All fish other than bass were released alive. All smallmouth bass were retained by MDIFW for growth and age analysis.

Length and age data were obtained from bass samples to document growth rates for comparison to historic data. These data were utilized to estimate first-year growth rates of smallmouth bass by back-calculating lengths at first annulus formation of age I (yearling) fish. When available, identical calculations were made from earlier samples (2002-2006) to compare YOY growth rates between years when flow bursts were implemented (2006) with years when flows were not intentionally manipulated in this manner (2002-2005). YOY growth through mid-September 2007 was estimated from actual lengths of fish collected with the electrofishing raft, described above. YOY growth was therefore likely underestimated for 2007 because the summer growing period was not yet completed.

The relative abundance of smallmouth bass and other sport fish was estimated from catch per unit of effort (catch/hour) data provided by an extensive network of voluntary anglers. A long-term dataset is available from volunteers from which trends in abundance, and other fishery metrics, are tracked.

3.0 RESULTS

3.1 <u>Nest Survey</u>

During June 2007, flows ranged between 400 and 2,600 cfs (Figure 1). Prior to the onset of spawning, heavy rains on June 6 resulted in discharge from Middle Dam between 2,000 cfs and 2,600 cfs from June 6 until June 9. Active spawning began the week of June 18 when discharge fluctuated between 800 and 1,100 cfs. After mid June, river discharge ranged from 800 cfs (June 25) to 400 cfs (June 28). Flows during the fry-monitoring phase ranged between 400 and 1200 cfs. Water clarity during the survey was excellent and underwater observations were completed in good light conditions (*i.e.* overcast, twilight or shaded conditions were avoided when possible).

Water temperature at Lower Dam during the survey ranged from a high of 20.1°C to a low of 16.9°C (Figure 2). Average ambient water temperature during the survey (6/25-7/3) was 18.4°C. Active spawning began the week of June 18th when high temperature was 20.2°C on June 19 and the low temperature was 16.7°C on June 24.

Figure 1. Average daily discharge (cfs) from Middle Dam, June 2007.

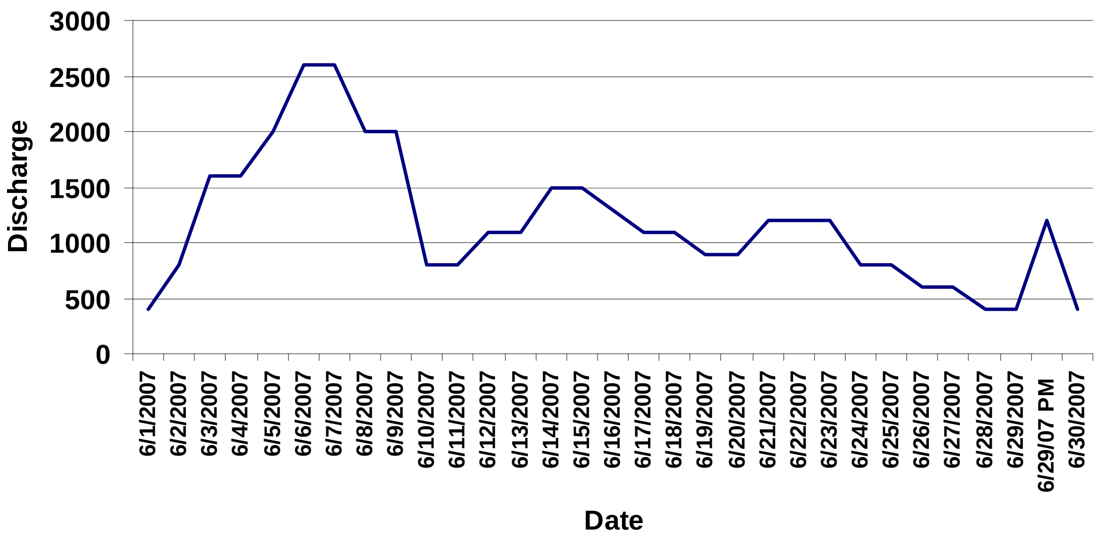
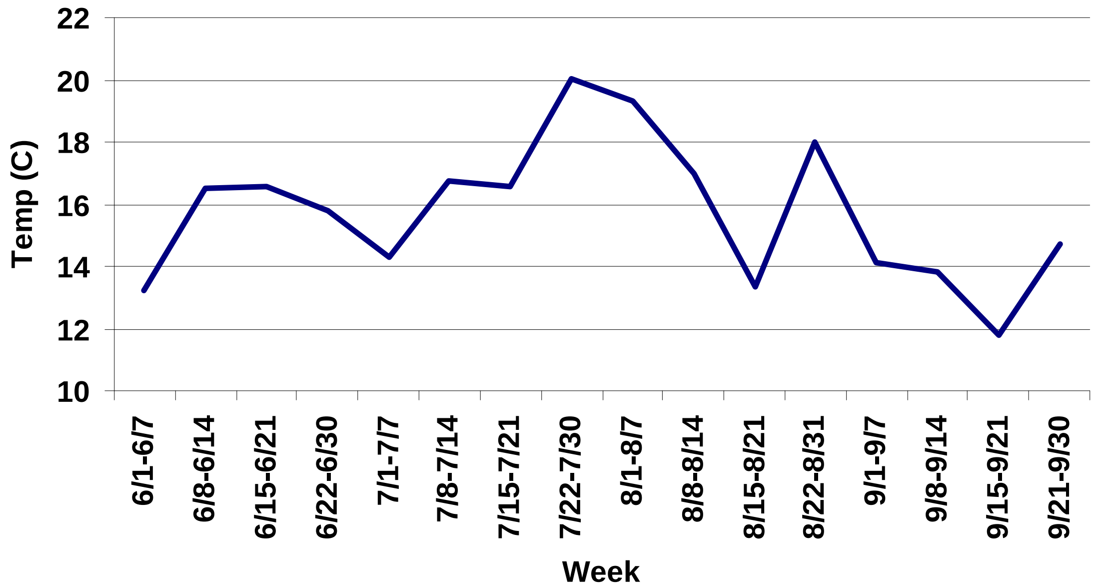


Figure 2. Average weekly temperature, June through September 2007, Middle Dam, Rapid River, Maine.



Smallmouth bass nests were most abundant in low gradient habitats such as pools, glides and runs. A limited number of nests in riffles and rapids were observed, but only in sheltered near-shore areas with steep banks providing shoreline depths of three feet or more. Most nests were in depths exceeding three feet at 400 cfs and were clearly associated with object cover. Collectively, nests near "poor" and "fair" cover (those potentially most vulnerable to pulse flow black fry attrition) accounted for approximately 36% (Table 2) of the 22 nests surveyed; 13.6% received a "poor" cover rating, and nests exhibiting "fair" cover accounted for 22.7% of total nests. Nests with "good" and "excellent" cover each accounted for 31.8% of the total. A much higher number of nests were established in poor/fair cover settings under the 2007 base flow conditions relative to 2006, when base flow conditions at the time of nesting exceeded 1,000 cfs.

Most nests were established in 3- 4 ft of depth at the base flow, though depths ranged from 1.5 ft (Upper Long Pool, ULP2) to 5 ft (Smooth Ledge) (Table 3). Nests were generally located adjacent to boulder cover or within a 2 ft distance. In many cases (CP1, SL3, LD1, and LD2) nests were located directly adjacent to boulder cover, and in some cases nests were found within spaces beneath boulders along the shoreline.

Table 2. Rapid River flow assessment. Distribution of cover classes observed during 2007 nest survey.

Cover Type	Percent Cover	Number of Nests	Total Percentage
Poor	0-25%	3	13.6 %
Fair	26-50%	5	22.7 %
Good	51-75%	7	31.8 %
Excellent	76-100%	7	31.8 %

Table 3. Rapid River flow assessment. Initial bass nests identified during June 2007.

				Approximate Counts of:				
Date	**Location**	**Nest**	**Depth to Nest (ft)**	**Eggs**	**Yolk Sac**	**Black Fry**	**Adult**	**Cover**
6/26	Long Pool	LP1	3	36	0	0	1	Poor
6/26	Long Pool	LP2	3	0	24	0	1	Good
6/26	Long Pool	LP3	4	50	50	0	1	Good
6/26	Long Pool	LP4	3	Present	0	0	1	Fair
6/26	Long Pool	LP5	4	0	0	0	1	Fair
6/26	Long Pool	LP6	4	0	0	0	0	Excellent
6/26	Long Pool	LP7	3	0	0	0	1	Excellent
6/27	Chubb Pool	CP1	3	Present	0	0	0	Fair
6/27	Chubb Pool	CP2	5	Present	0	0	1	Poor
6/27	Lower Dam	LD1	2	96	0	0	1	Excellent
6/27	Lower Dam	LD2	3	0	36	0	1	Excellent
6/28	Upper Long Pool	ULP1	4	120	0	0	2	Excellent
6/28	Upper Long Pool	ULP2	1.5	0	100	0	1	Good
6/28	Upper Long Pool	ULP3	2	0	0	0	0	Good
6/28	Upper Long Pool	ULP4	3	0	0	0	0	Excellent
6/28	Upper Long Pool	ULP5	2	0	0	0	2	Excellent
6/28	Cold Spring Pool	CSP1	3	0	0	150	1	Good
6/28	Cold Spring Pool	CSP2	2	0	50	0	0	Fair
6/28	Smooth Ledge	SL1	2	0	0	24	0	Poor
6/28	Smooth Ledge	SL2	2	0	0	24	1	Fair
6/28	Smooth Ledge	SL3	0.5	0	0	100	0	Good
6/28	Smooth Ledge	SL4	5	0	0	0	1	Good

3.2 Effects of the 400 cfs to 1,200 cfs Pulse on Black Fry Swim-up

Fourteen nests selected for flow pulse testing were marked with a GPS unit (Figures 3 and 4) at the conclusion of the initial survey. Photographs of each nest are included in Appendix A. Results of flow pulse releases are presented in Table 4.

June 26 - 28, 2007

Chub Pool: One active nest was located at Chub Pool along the right (north) bank adjacent to boulder cover.

Lower Dam: Two nests were located near Lower Dam. LD1 was located upstream from the remnants of Lower Dam within a boulder field. LD2 was located directly adjacent to the left (south) bank immediately downstream of the dam structure. Both of these nests ranked as having excellent cover.

Upper Long Pool: Two nests selected for fry monitoring were located along the south bank. ULP1 was located upstream of a short riffle. ULP2 was located downstream of ULP1 between two riffles. Cover ranged from good (ULP2) to excellent (ULP1). Cover for both nests consisted of boulders within 1 ft. of the nest.

Long Pool: Four study nests were located. LP1 and LP4 were located in a small boulder field in slower moving water, center channel toward the base of the riffle entering Long Pool, in the same locations as in 2006. LP2 and LP3 were in center channel further downstream from the small beach. Cover for these nests ranged from poor (LP1) to good (LP2 and LP3). Cover for all nests consisted of boulders within 2 ft of nest perimeter.

Cold Spring Pool: Two nests at Cold Spring Pool were positioned along the left bank. CSP1 occurred immediately below the riffle entering the pool on the backside of a large boulder at a depth of 3 ft. CSP2 was located downstream from CSP1. Cover ranged from poor (CSP2) to good (CSP1).

Figure 3. Rapid River flow assessment. Study nest locations above Lower Dam.

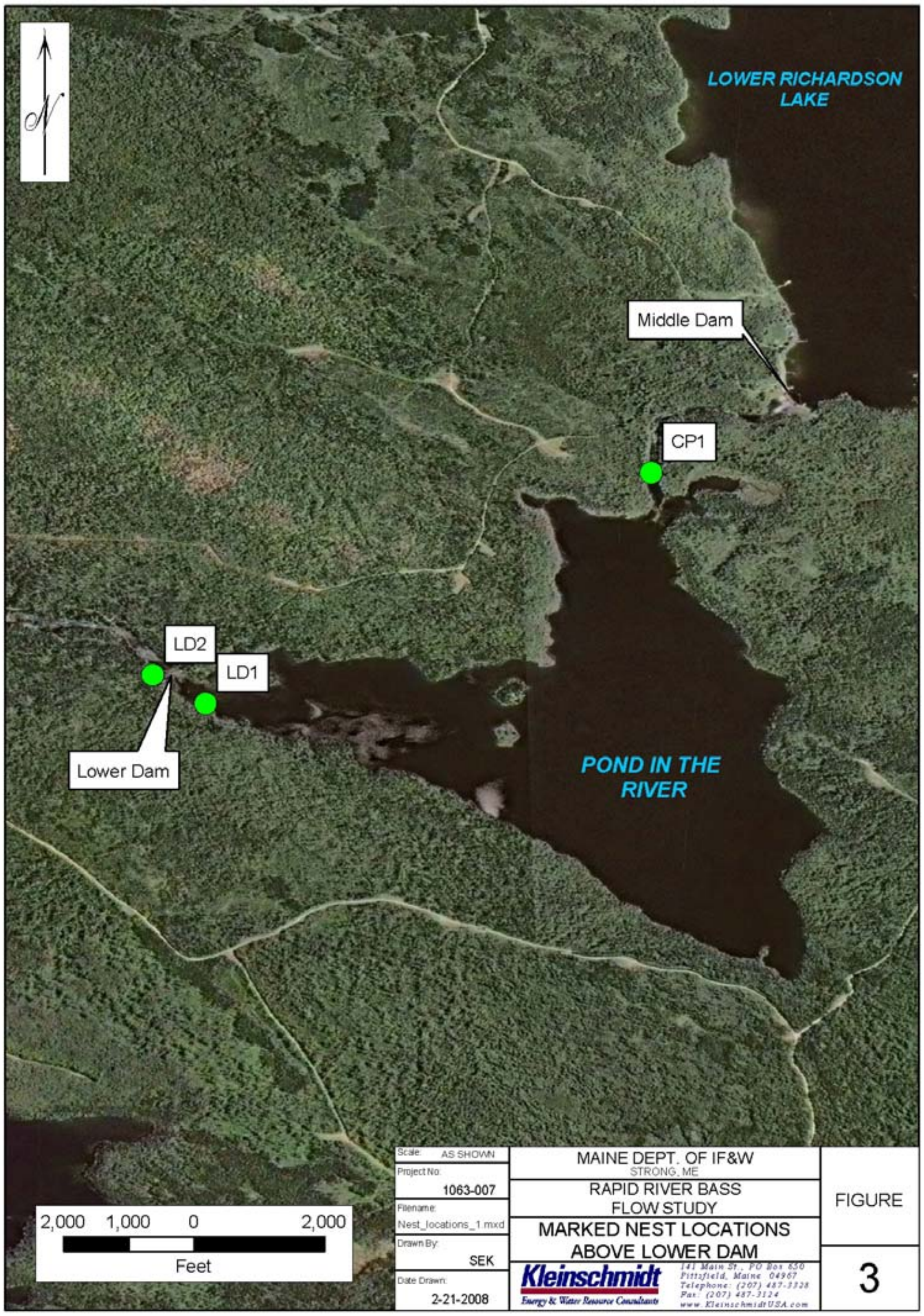
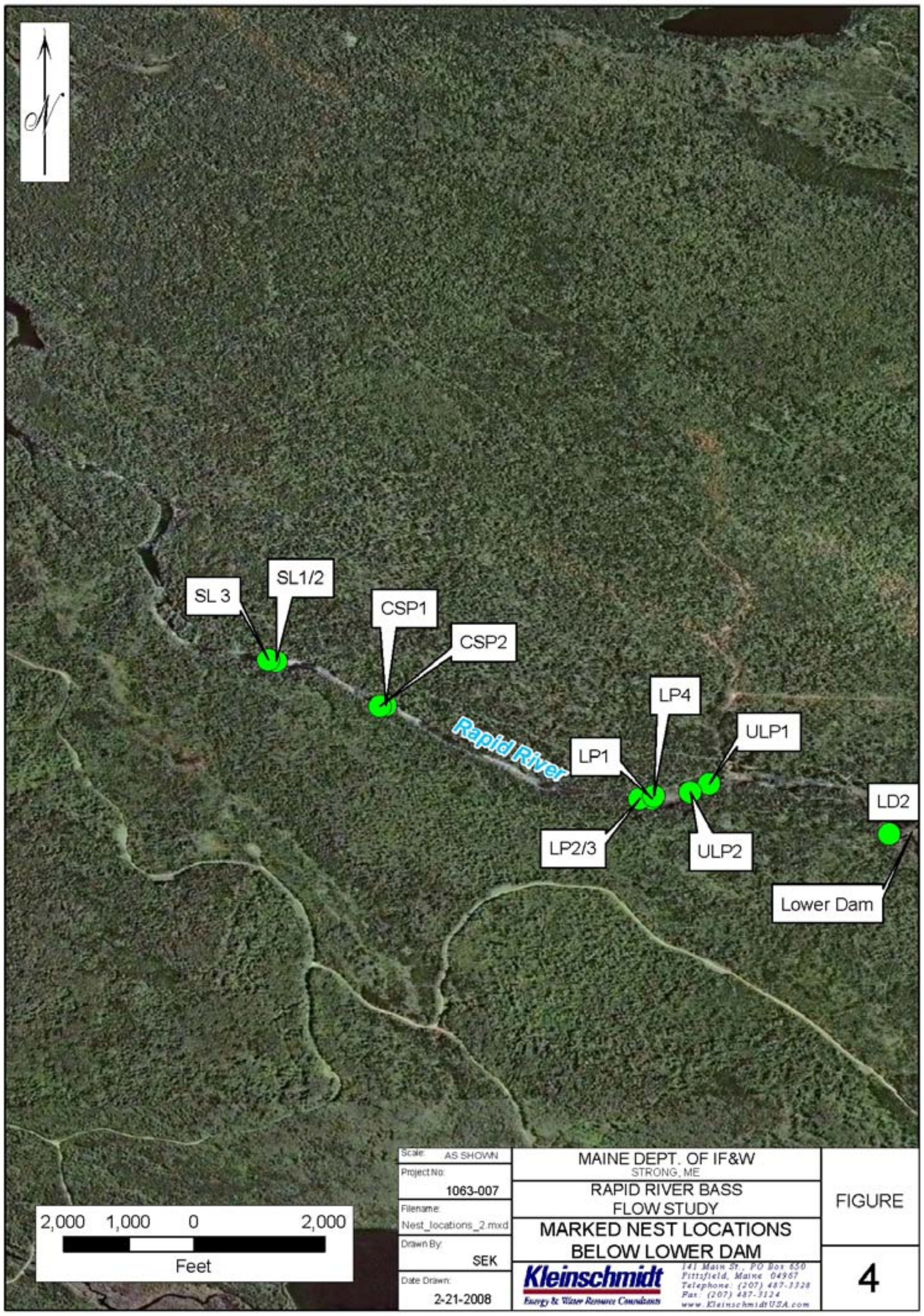


Figure 4. Rapid River flow assessment. Study nest locations below Lower Dam.



Smooth Ledge: Three study nests were constructed in similar locations as nests observed in 2006. All were located along the right bank in a small side channel adjacent to, or downstream from the island. SL1 and SL2 were located in a depression at the upstream limit of the side channel, while SL3 was located at the downstream end of the small island. Cover ranged from poor (SL1) to good (SL3) and consisted of boulders within 0.5-2 ft of the nests.

<u>June 29, 2007</u>

An unanticipated flow release of 1,200 cfs occurred overnight on June 28, followed by resumption on June 29 of the base flow of 400 cfs. Although only four nests hosted black fry at that time, nests were resurveyed the following day, and showed signs of change (Table 4).

Chub Pool: The single nest located at Chub Pool (CP-1) was evacuated of all bass eggs - initially this nest had eggs.

Lower Dam: LD1 was observed to have eggs present in more limited numbers than identified in the initial survey. Sac fry abundance at LD2 appeared to have increased (possibly due to field conditions).

Upper Long Pool: ULP1 was completely evacuated. ULP2 contained 30% fewer sac fry.

Long Pool: No significant changes in abundance were observed.

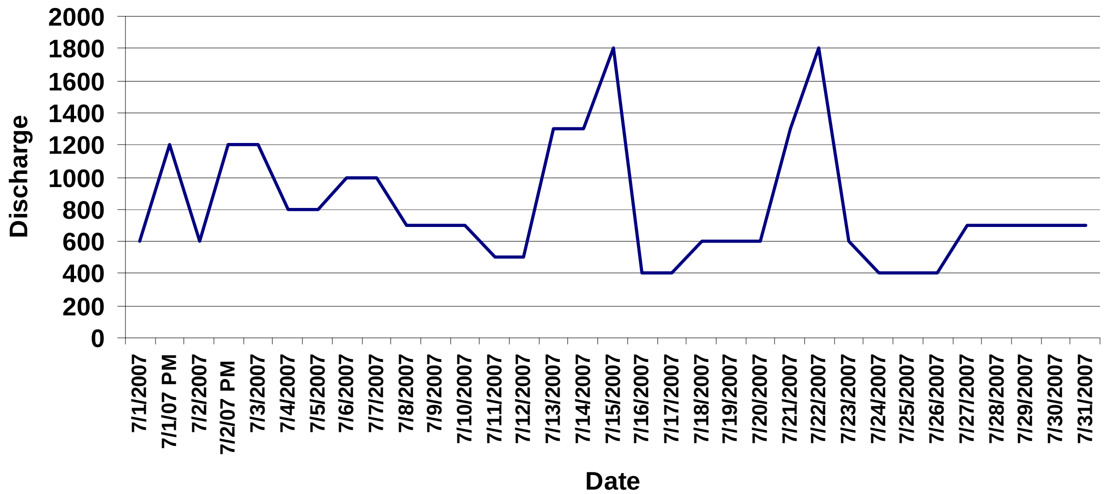
Cold Spring Pool: No significant changes occurred, though egg abundance at CSP2 was slightly reduced.

Smooth Ledge: Lower numbers of fry on SL1 and SL2 may have been related to observation error because subsequent examination revealed higher numbers of fry. Fry abundance at SL3 appeared to increase, which may also have been due to observation error.

July 2, 2007

Flow releases on July 2 and 3 were timed to coincide with optimal black fry emergence. A scheduled overnight flow pulse of 1,200 cfs was made on July 1, 2007 prior to arrival of the field crew. Figure 5 shows Middle Dam discharge for July.

Figure 5. Average daily discharge (cfs) from Middle Dam, July 2007.



Lower Dam: LD1 was completely evacuated. LD2 contained approximately 120 black fry, likely having matured from the previously-observed sac fry.

Upper Long Pool: ULP1 and ULP2 were completely evacuated.

Long Pool: LP1 and LP2 were populated with black fry, sac fry abundance in LP3 was unchanged, and LP4 was completely evacuated.

Cold Spring Pool: Black fry abundance at CSP1 was greatly reduced from the prior observation. CSP2 also had fewer black fry and no remaining sac fry.

Smooth Ledge: The side channel area where the nests were located made observation of fry difficult as the fry had moved out from the nests. SL1 and SL2 still had a small number of black fry present, but given survey error, may be considered as unchanged. Black fry abundance at SL3 was significantly reduced.

July 3, 2007

A flow pulse of 1,200 cfs was released overnight on July 2, 2007.

Lower Dam: The abundance of black fry at LD2 was significantly lower than observed on July 2.

Long Pool: Black fry abundance at LP1 and LP2 decreased from July 2. The black fry count at LP3 increased, and sac fry were absent. Black fry abundance at LP3 likely reflected maturation of sac fry rather than a flow pulse effect.

Cold Spring Pool: Black fry abundance at CSP1 increased. This may reflect unobserved sac fry recruitment or field count error. CSP2 was completely evacuated.

Smooth Ledge: Black fry abundance at SL1 and SL2 varied slightly from the prior day, and black fry abundance at SL3 was greatly reduced.

Six out of the fourteen study nests (43%) produced no black fry because they were completely evacuated of early lifestages prior to or at the black fry life stage after one or more pulse treatments (Table 5). Three of the six were "fair" cover nests, two were "excellent" cover nests, and one was a "good" cover nest. Three nests (21%) showed partial attrition of black fry - one each of "poor", "good", and "excellent" cover types. One (7%) nest ("good" cover) showed no decrease in the life stages present after the flow pulses.

Table 4. Rapid River flow assessment – post-flow release life stage totals for monitored nests.

	Pre-Release			6/29/2007			7/2/2007			7/3/2007		
Nest	**Eggs**	**Sac fry**	**Black fry**	**Eggs**	**Sac fry**	**Black fry**	**Eggs**	**Sac fry**	**Black fry**	**Eggs**	**Sac fry**	**Black fry**
LP1	36	0	0	36	0	0	0	0	12	0	0	6
LP2	0	24	0	0	30	0	0	0	150	0	0	80
LP3	50	50	0	0	50	0	0	50	0	0	0	120
LP4	Present	0	0	0	50	0	0	0	0	0	0	0
CP1	Present	0	0	0	0	0	0	0	0	0	0	0
LD1	96	0	0	50	0	0	0	0	0	0	0	0
LD2	0	36	0	0	120	0	0	0	100	0	0	50
ULP1	120	0	0	0	0	0	0	0	0	0	0	0
ULP2	0	100	0	0	70	0	0	0	0	0	0	0
CSP1	0	0	150	0	0	150	0	0	60	0	0	100
CSP2	0	50	0	0	36	0	0	0	10	0	0	0
SL1	0	0	24	0	0	5	0	0	12	0	0	48
SL2	0	0	24	0	0	5	0	0	12	0	0	5
SL3	0	0	100	0	0	200	0	0	70	0	0	24

Table 5. Rapid River flow 2007 assessment. Effectiveness of 1,200 cfs flow pulses at evacuating early life stages of smallmouth bass from study nests.

Nest ID	Cover Class
LP1	Poor
LP2	Good
LP3	Good
LP4	Fair
CP1	Fair
LD1	Excellent
LD2	Excellent
ULP1	Excellent
ULP2	Good
CSP1	Good
CSP2	Fair
SL1	Poor
SL2	Fair
SL3	Good

Legend:

fully evacuated **partially evacuated** **no apparent effect** **inconclusive**

Changes in abundance in four few study nests were inconclusive. In these cases, black fry abundance increased following flow pulses, or eggs or sac fry counts varied erratically between surveys. These sources of error may have resulted from displacement among neighboring nests, within-nest overnight maturing of sac fry to the black fry stage, or observer counting error. For example, black fry at CSP1 were actively darting in the current, making an accurate count difficult. SL1 and Sl2 were in close proximity to each other, and the nest affinity of individual black fry observed moving throughout that vicinity may not have been clear to the observer.

3.3 Young-of-Year (YOY) and Yearling Smallmouth Bass Monitoring

There is evidence that erratic flows during the spawning and incubation period was correlated with smallmouth bass growth in the Rapid River (Table 6). Backcalculated lengths to age I of yearling bass collected since 2002 indicate that first-year growth of bass was lowest in 2006 and 2007 – the two years during which high flows were provided during the spawning period, either naturally, artificially through this study, or both. Moreover, YOY bass growth may have been depressed in 2005 when high natural flows in June and July occurred. Conversely, the years 2003 and 2004 both experienced relatively stable, low flows during the June-July period, which may have enhanced smallmouth bass reproduction and growth during those years.

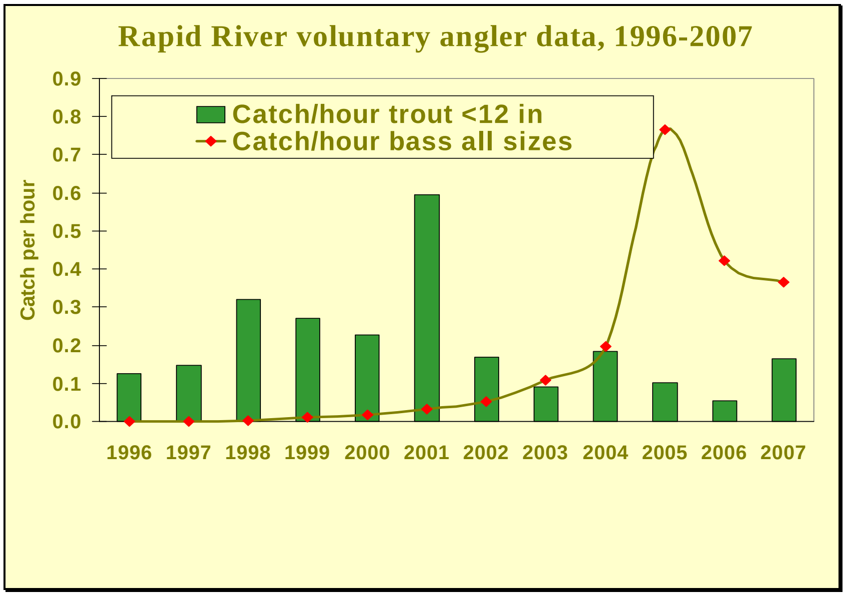
Table 6. Backcalculated lengths to first annulus of age I smallmouth bass from the Rapid River, 2002-2007[2].

Growth Season	Mean Backcalculated Length (mm) of Age I Bass (±SE)	Sample size	Median flow (CFS) June 15-July 15	Mean flow (CFS) June 15-July 15	Max. daily flow (CFS) June 15-July 15
2002	72.1±0.5	33	800	1,171	3,300
2003	Data unavailable		682	656	932
2004	70.3±2.8	4	590	516	590
2005	69.1±0.7	40	900	961	2,800
2006	66.9±0.9	20	800	1,000	3,000
2007	61.5±2.3	13	800	900	4,500

Bass catch rates (catch/hour) provided by volunteers declined considerably in both 2006 and 2007 (Figure 6), suggesting that conditions for good growth, high over-winter survival, and recruitment to age I was poor during 2005 and 2006. The predominant sizes of bass reported by anglers – 3 to 6 inches in length – are generally yearling and age II fish (MDIFW, unpublished data), so it seems likely that the decline in catch rates in 2006 and 2007 was related to low recruitment of the 2005 and 2006 brood years. Catch rates for young brook trout (<12 inches and ages I+ and II+) increased slightly in 2007, perhaps in response to lower bass recruitment noted above (Figure 6).

[2] 2007 data values were from late-September samples of age 0+ bass, and probably underestimate total growth achieved for that year.

Figure 6. Catch rate trends for smallmouth bass and juvenile brook trout in the Rapid River, 1996-2007. Data provided by voluntary anglers.



4.0 DISCUSSION

4.1 Nest Distribution and Pulse Flow Effectiveness

Comparison of the timing of the 2006 and 2007 spawning events suggests some inter-annual predictability. The timing of the onset of riverine smallmouth bass spawning appears to be linked closely to temperature (Graham and Orth 1986). In 2006, ambient river temperature did not consistently exceed 20^{o}C until the final week of June (Kleinschmidt Associates, 2007), after which nesting and hatching progressed rapidly, whereas in 2007 this threshold was reached June 19. Although nesting was initiated earlier in 2007, fluctuating water temperatures resulted in abandonment of early nests, and subsequent delays in embryo development. Nests constructed later in June were more stable and thus the timing of black fry life stage emergence was ultimately similar both years, despite differences in June flow and temperature conditions. Nests were "ripest" with black fry between June 27 and July 3, 2007, sequential nesting cohorts were again observed, and timing of the emergence of black fry followed generally similar dates on both years, with peak black fry abundance occurring after July 1. The late June 2006 extreme high flow events that resulted in nest destruction and/or abandonment and subsequent re-nesting did not occur in 2007.

Some nest sites selected by smallmouth bass showed a very strong spatial affinity in 2006 and 2007, especially at Long Pool and Smooth Ledge. In 2007, however, more nests were constructed in "poor" and "fair" cover at a base flow of 400 cfs than in 2006 when the base flow exceeded 1,000 cfs, consistent with observations from other studies (Lukas and Orth 1995). The riverwide survey also revealed that nests were not infinite and scattered throughout all habitats but rather were finite in number and concentrated in specific, low-gradient pools, runs and glides.

A total of three flow pulses were monitored in 2007. The goal of these study pulses was to evaluate the effect of pulses on black fry. However, the unscheduled June pulse occurred when early life stage development was dominated by egg and sac fry lifestages. Nevertheless, observations made following this release provided supplemental information showing nest abandonment.

Of the study nests where conclusive data were gathered, approximately 60% showed at least some loss of fry following flow pulsing. The 400/1,200 cfs base flow/pulse flow fluctuations appeared to completely curtail spawning success at approximately 40% of all study nests, based on the combined effects of nest abandonment and black fry attrition. An additional approximately 20% of nests were at least partially evacuated of sac fry or black fry. Nests that were entirely evacuated included examples classified as “excellent”, “good” and “fair” cover, with no clear pattern of dominance by cover type. Partially evacuated nests also included “excellent”, “good” and “poor” cover types. Although there was no clear pattern among cover types, circumstances dictated that relatively few “poor” cover type nests were available for assessment. It is possible that with data from a larger sample size of “poor” cover nests, that the relative effectiveness of pulses on that nest category would be higher.

4.2 YOY Growth and Recruitment

Smallmouth bass growth in the Rapid River appeared to be negatively correlated with erratic flows during the spawning and incubation period, although growth was likely also influenced by other factors, including water temperatures, late winter flow rates, and the relative size of preceding and succeeding bass cohorts (intraspecific competition). Moreover, bass recruitment, as measured from angler catch rates, declined coincidentally with our flow burst experiments and our estimates of declining bass growth rates. Precisely determining the specific mechanism(s) for the observed growth and recruitment declines was beyond the scope of this study, but the scientific literature and MDIFW’s experience strongly support the idea that erratic riverine flows played a significant role.

Numerous studies have shown that riverine smallmouth nesting success is in part dependent upon benign spring flows, *i.e.* stable, low velocity microhabitat conditions during the period that fry are vulnerable. Many of these studies have shown a correlation between year class strength and prevailing flows during the spawning, incubation and fry season, which on the Rapid River appears to begin the third week of June and extend through the first week of July. The degree to which this affects nesting success likely varies according to localized habitat conditions, such as the distribution and quality of object cover associated with spawning sites. This study suggests that in the Rapid River, pulsing flows will conservatively impair approximately 50% of the smallmouth bass nest spawning success in riverine habitats.

Flow pulses in the Rapid River can therefore be expected to diminish, but not entirely eliminate fry production. However, summer season flow pulses may also negatively impact those fish that survive to the Young-of-Year (YOY) life stage, and thus act to depress year class success.

Post-larval YOY bass also require suitable flows in nursery habitat to achieve abundance and contribute to the population (Smith *et al.*, 2005). Flows that are two low may reduce habitat area and forage drift, forcing competition among bass, while flows that are too high will stress YOY bass growth by reducing resting refugia and forcing fish to divert calories from growth toward locomotion (maintaining position in the current). Smith et al.(2005) found that "*Regardless of the actual causal mechanisms, we noted a distinct decrease in smallmouth bass recruitment success associated with both high and low streamflows.*"

This study and MDIFW data suggested a negative correlation between erratic flows and bass recruitment, although the extent to which the two were related could not be precisely determined. Flow pulses, however are not expected to affect smallmouth bass recruitment from Pond in the River. There was evidence, however, that brook trout recruitment stabilized concurrently with declining bass recruitment. Given the high value of the Rapid River's native brook trout population, and the limited ability of fishery managers to control abiotic stressors on bass, continuing a program to provide stressing flows from Middle Dam seems desirable.

5.0 CONCLUSIONS

- The current study documented the mechanisms and extent to which flow pulses may mechanistically affect riverine smallmouth bass reproduction in the Rapid River.
- Although the timing of the onset of spawning appears to be driven by water temperature, early brood development is elastic and black fry appear to consistently reach their greatest abundance and vulnerability during the week spanning the end of June and beginning of July.
- Not all nests ripen at exactly the same time because spawning occurs in temporal cohorts spaced several days apart.
- Some nesting sites are reused annually, while other sites are selected according to prevailing base flows.
- Habitat types where nesting occurs are concentrated in areas with low velocity and depths between 3-5 ft at all flows. These are:
  - Littoral areas of deep pools,
  - Runs / glides, and
  - Rapids and riffles – only in isolated pockets of stream margins with sufficient depth and cover[3].
- The 1,200 cfs pulse flows were approximately 50% effective overall at causing nests to fail to produce viable offspring[4]. This estimate is conservative because it is based on observations from a data set dominated by good and excellent-cover type nests available as study nests. Fry attrition from poor cover nests that could not be documented is expected to be qualitatively higher.
- The data suggested a negative correlation between erratic flows and bass recruitment; continuing a program to provide stressing flows from Middle Dam seems desirable.

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[3] No nesting was observed in rapids and riffles lacking sufficient depth and cover.

[4] i.e. A weighted estimate based on observation that early lifestage attrition occurred at 40% of all nests, and partial attrition occurred at an additional 20% of nests.

6.0 PRELIMINARY RECOMMENDATIONS

- Consult with FPL Energy Maine (FPLE) to develop and implement a Middle Dam flow pulsing plan for drought, normal and wet years that can function within inherent limitations of water availability, and competing water uses (as identified in Kleinschmidt Associates, 2006). The plan should include provisions for timing (e.g. specific date ranges, duration, time of day to mitigate angler impacts), as well as late winter flows.
- Continue to monitor basic population and fishery metrics for all the river's predators (brook trout ,landlocked salmon, smallmouth bass), other native fishes, and crayfish, per the detailed plan already designed and implemented by MDIFW.
- Continue to inform other fisheries professionals and the public of our research and management findings.
- Continue to stay abreast of new research findings that relate to mitigation strategies regarding smallmouth bass control and interactions with native fishes.

7.0 LITERATURE CITED

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ATTACHMENT A

PHOTOGRAPHS OF STUDY SITES

Photo Plate 1. **Chub Pool. Looking upstream from CP1, nest located behind boulders near shoreline.**

Photo Plate 2. **Lower Dam. View looking upstream from LD1.**

Photo Plate 3. **LD1. View of Nest LD1. Nest located at orange marker adjacent to boulder cover (Rank of cover excellent).**

Photo Plate 4. **Long Pool. View upstream, LP 4 located at photo left.**

Photo Plate 5. **Long Pool. View looking across nest LP 2. Nest is in depression in boulder cover.**

Photo Plate 6. Long Pool. Nest LP4, Nest is located at the diver's position in a depression.

Photo Plate 7. **Upper Long Pool. View looking upstream.**

Photo Plate 8. **Upper Long Pool. ULP 2, View of nest adjacent to boulder cover (Rank of cover, good).**

Photo Plate 9. **Cold Spring Pool. CSP1, located directly behind large boulder at photo.**

Photo Plate 10. **Cold Spring Pool. View upstream from nest CSP2. Nest located within cover along the shoreline.**

Photo Plate 11. **Smooth Ledge. View upstream from entrance of side channel.**

Photo Plate 12. **Smooth Ledge. SL1, View of nest SL1 located at photo center marked by an orange marker (cover type -"Poor").**

Photo Plate 13. Smooth Ledge. View upstream from nest SL3. SL1 and SL2 located in side channel upstream of in stream boulder cover.